# Termination of Irrigation on Corn

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## ABSTRACT

A test was conducted for three years on the termination of corn irrigation in southeast Missouri (SEMO). Results showed that the location of the milk line can be an excellent tool of when to determine when to terminate irrigation. Based on the relative low cost of irrigation water in SEMO, corn should be irrigated past ½ milk stage and even as far as the ¼ milk stage.

## INTRODUCTION

One of the most frequent questions that county extension agents are asked by local irrigators is when should irrigation be terminated on corn and other crops. Cutting off irrigation too early can reduce final yield by decreasing the overall weight of the corn kernels, which produces low *test weight,* (the number of pounds required to fill a bushel). The standard test weight of corn is 56.0 pounds per bushel. Test weight is hybrid-linked and data on it is normally provided by seed companies in their literature as a scale value from 1 to 9. Assuming correct population levels, lower then normal test weights are often associated with inadequate late-season irrigation.

### Physiology of Corn

The number of ears per plant and number of kernels per ear are primarily determined during the vegetative stages of growth. Many of today's high-yielding hybrids are non-prolific (they tend to form single ears per plant), but the prolific varieties determine the number of ears per plant during R5. The potential size of the ear and the number of potential kernels, or ovules, down the ear is determined in V12. The final number of sites for kernels down the cob row is determined a week prior to silking in V17 stage. During silking (R1) the ovules which are fertilized can grow into kernels. The ultimate yield then is determined by the number of kernels per acre that exist times the average weight per kernel.

Thus, from ten weeks after emergence final kernel weight becomes the prime influence on yield. During the blister stage (R2) starch begins to accumulate. Towards the end of the dough stage (R4), as the starch levels begin to increase the kernels begin to dent on top as moisture level decreases in the kernel. The final stage prior to physiological maturity is the dent stage (R5) where starch accumulation and kernel drying continue occurring. The moisture level is at 55% as the beginning of dent stage. At physiological maturity (R6), also called black layer, the moisture level has decreased to 30-35% and no further starch accumulation occurs (Ritchie et al., 1993).

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During the six or seven weeks that transpire between the R2 and R6 stages kernel weight increases. If soil moisture becomes insufficient during this time yield decreases. The final irrigation should take place late enough in the season to ensure that the plant will have full potential to maximize the weight of the kernels. Management factors that must be accounted for is the tendency of root mass to diminish late in the season and the need of adequate hydration within the plant to allow for translocation of nutrients to the seed from other plant parts.

Early Work at Estimating Cut-off

Earlier attempts to ascertain when to end irrigation (e.g., Klocke et al., 1991) relied on a mass balance approach that used estimated soil moisture-holding capacity, rooting depth, and allowable depletion point to calculate a storage amount of water. Daily crop water use information from the tail-end of the season was then utilized to calculate an equivalent amount of water and the associated number of days back from black layer this point was reached. Several state Extension services followed this methodology in formulating their recommendations. Problems with the mass balance method was that it involved calculations and use of three tables (which might put off many farmers), plus it involved an estimation of current soil moisture status that the farmers might not have. In addition, the results did not always coincide with empirical studies (Alam, 2000), being too conservative and causing irrigation to be terminated too soon.

Henggeler (2002) developed a method of deciding when to terminate irrigation by soil type and irrigation method based on visual appearance of the corn ear, primarily milk line location. The procedure for this was based on the methodology of Klocke et al. (1991), but the rooting depth factor was reduced to only 1.5 feet, instead of 3.0 feet. This was done to reflect earlier water use studies of corn in SEMO that showed little water extraction beneath 18 inches. The impact of soil type was incorporated into the procedure by using irrigation deficit values used by the University of Arkansas (Ferguson et al., 1999) and from unpublished empirical studies by the University of Missouri.

## METHODS and MATERIALS

A test was conducted for three years (2003-2005) on two separate soil types to determine when irrigation should be terminated on corn. The soils involved were a medium textured soil (Tiptonville silty loam) and a course textured soil (a Broseley Loamy Fine Sand and Bosket Fine Sandy Loam combination). The computer irrigation scheduling program, *Arkansas Scheduler* (Ferguson et al., 1996), was used to determine when to irrigate. Following the application of a new irrigation, a set of replicates was then excluded from receiving any additional irrigations. In this manner treatments were created based on when the last irrigation was applied. Replicate number was three or four depending on the size of the field available for the test.

The overall goal of the project was to develop visual keys based on the appearance of the crop for terminating irrigation for the season. In the first year of the study a single hybrid was used. In subsequent years four different hybrids were used to offset the possibility of results being skewed by innate traits one particular hybrid might possess. The ear with husk, stripped ear, cross-section of the ear, and crop canopy were photographed approximately every ten days starting about silking. Starting in 2004 kernel moisture and the position of the milk line was measured. The milk line was determined by inserting the end of a tack into the kernel to locate the demarcation between the solid starch area and the liquid portion of the kernel.

Yield was determined by harvesting two rows of corn with a plot combine. Test weight was measured by weight a know volume of seed. Both yield and test weights were adjusted to a 15.5 % moisture level. Relative yield was determined by dividing all yields by the highest yield from that test.

## RESULTS

The 2004 year, which was an anomaly year for crop production in Missouri with historic yield levels in corn, soybean, sorghum, rice and cotton, was not used since the normal trends did not occur between yield and water applied.

The relative yields are shown plotted against the accumulative corn heat units (cHUs) (base = 50° and maximum temperature = 86°) from emergence to the last irrigation. The manufactures' estimate of cHUs required to reach black layer for the hybrids used was 2700-2800. The results (Fig. 1) tended to show that irrigation was often beneficial to about 2400 cHUs.

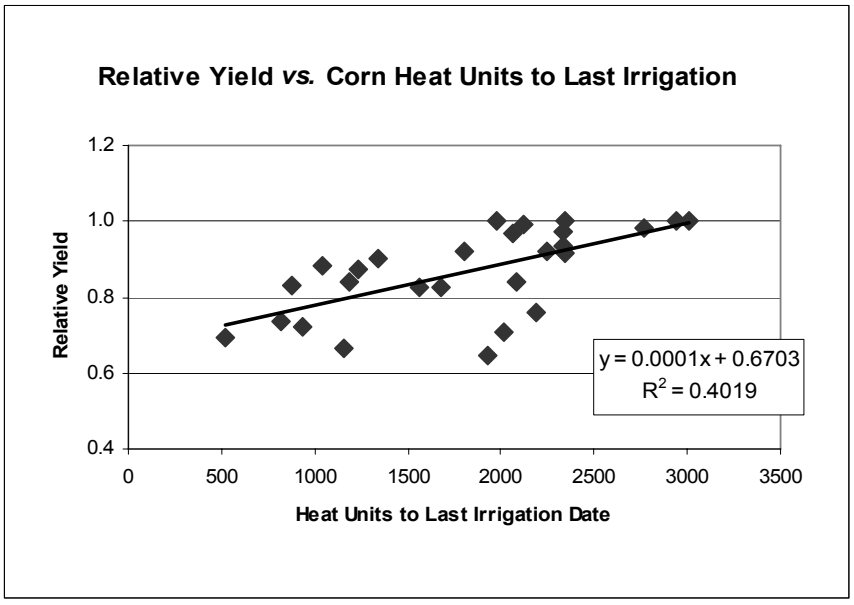


**Fig. 1.—Relative yield versus corn heat units to the last irrigation.**

The visible milk line was generally higher up the kernel then the actual milk line that demarks the solid and liquid area of the kernel, as shown in figure 2. The period of time it takes for the milk line to travel down from the crown to the tip of the kernel took longer then the time period of twenty or thirty days, which is often quoted in the literature (e.g., MSU, 2005). This commonly quoted rate change produces a percentage milk line change rate of about 4% per day. The study showed about a 2.2% rate change per day.


**Fig. 2.—Cross-section of corn ear showing milk line. Percentage of milk line = l / L.**

Many of the last irrigations in the tests were applied before R5 when the milk line has not yet been formed. Cutting off irrigation before the milk line appears is clearly too early and the average relative yield for these treatments was only 0.80. The average relative yield for all treatments where the last irrigation occurred once the milk line process was beginning was 0.90. .Figure 3 indicates that overall irrigation should continue until about 1/3 milk line remains.

This recommendation needs to take into account the cost of pivot irrigation. Currently, there is a large difference in cost between electricity and diesel/propane. The average cost for the electricity is about $2.40 per inch versus $4.20 per inch for diesel/propane. Growers will need to keep this in mind in determining when to apply the last irrigation.

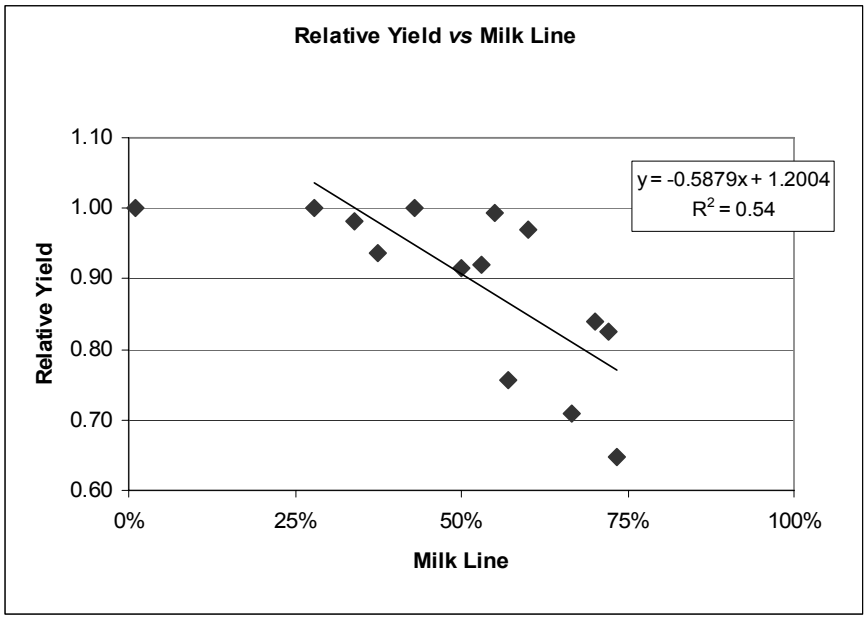


**Fig. 1.—Relative yield versus position of milk line.**

## CONCLUSIONS

- The location of the milk line serves as a good indication of when to terminate irrigation.
- For Missouri conditions, irrigation should occur pass the 25% milk line for electricity users and pass the 50% milk line for diesel/propane users.
- The progression of milk line appears to take 40 to 50 days, and is slower then what is often reported (20 to 30 days).
- Test weight values can help determine if irrigation was carried long enough into the season.

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